



# Stony Creek Floodplain Risk Management Plan

Job Number LJ2597

Prepared for Lake Macquarie City Council

Final - December 2011



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## Foreword

The NSW Government Flood Policy is directed towards providing solutions to existing flood problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the policy, the management of flood prone land is the responsibility of Local Government. The State Government subsidises flood management measures to alleviate existing flooding problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities. The Commonwealth Government also assists with the subsidy of floodplain management measures.

The Policy identifies the following floodplain management 'process' for the identification and management of flood risks:

1. Formation of a Committee	Established by a Local Government Body (Local Council) and includes community group representatives and State agency specialists.
2. Data Collection	The collection of data such as historical flood levels, rainfall records, land use, soil types etc.
3. Flood Study	Determines the nature and extent of the floodplain.
4. Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed development.
5. Floodplain Risk Management Plan	Involves formal adoption by Council of a management plan for the floodplain.
6. Implementation of the Plan	This may involve the construction of flood mitigation works (eg culvert amplification) to protect existing or future development. It may also involve the use of Environmental Planning Instruments to ensure new development is compatible with the flood hazard.

The Stony Creek Flood Study was completed by Cardno Lawson Treloar in 2005 to define flood behaviour in the catchment. This Floodplain Risk Management Study and Plan has been prepared for Lake Macquarie City Council and the Department of Environment and Climate Change by Cardno Lawson Treloar. This report forms the fourth and fifth stages of the management process for the Stony Creek catchment.

## Executive Summary

Lake Macquarie City Council commissioned Cardno Lawson Treloar to prepare a *Floodplain Risk Management Study* and *Floodplain Risk Management Plan* for Stony Creek. This document forms the Floodplain Risk Management Plan, and should be read in conjunction with the Floodplain Risk Management Study.

Flooding in the Stony Creek catchment can pose a high hazard to some residents living within close proximity to the creek. The purpose of this study is to identify and examine options for the management of flooding and make recommendations for actions to be adopted as part of the Floodplain Risk Management Plan.

The Stony Creek catchment has a total area of 46.4 km<sup>2</sup> discharging into Fennell Bay. The upper part of the catchment lies above the Newcastle-Sydney railway line and is primarily bushland area comprising Awaba State Forest. Downstream of the railway line is the industrial and residential area of Toronto and Blackalls Park. Stony Creek and Mudd Creek discharge downstream of Railway Parade into Edmunds Bay and Fennell Bay.

In the past, flooding in the catchment has caused property damage and posed a hazard to residents. A major flood occurred in February 1981, with more recent flooding occurring in June 2007.

The study area is exposed to two forms of flooding: Lake Macquarie flooding and local catchment flooding. Generally, areas downstream of Railway Parade experience more significant flooding due to Lake Macquarie than local catchment flooding. In contrast, areas upstream of Railway Parade are dominated by local catchment flooding. Full details of the flood modelling for the existing conditions can be sourced from the Stony Creek Flood Study (Cardno Lawson Treloar, 2005).

The table below summarises the number of properties that would be flooded in a range of design flood events together with the flood damage that is likely to occur under present conditions.

Flood ARI	Properties with Over-floor flooding	Flood Damage
5 Year ARI	0	\$ 164,108
10 Year ARI	4	\$ 497,645
20 Year ARI	10	\$ 951,638
50 Year ARI	29	\$ 1,855,372
100 Year ARI	57	\$ 3,085,200
200 Year ARI	87	\$ 4,389,976
PMF	295	\$22,640,498
Average Annual Damage		\$247,000

This Floodplain Risk Management Study investigates what can be done to reduce or manage the effects of flooding in the catchment. The Floodplain Risk Management Plan recommends a mix of strategies to manage the risks of flooding.

Using the merits-based approach advocated in the NSW State Government's Floodplain Development Manual (2005) and in consultation with the community, Council and state agency stakeholders, a number of potential options for the management of flooding were identified.

These options included:

- flood modification measures;
- property modification measures; and
- emergency response measures.

An extensive list of options was assessed against a range of criteria (technical, economic, environmental and social). Hydraulic modelling of some of the flood modification options was undertaken to provide a comprehensive analysis of those options that would involve significant capital expenditure.

The assessment found that the highest scored flood modification options to be recommended included:

- FM1.2 – Detention basin upstream of railway line – 1 site
- FM3.1 – Levee at West Toronto industrial area
- FM4.7 – Remove dis-used railway line at Railway Parade on Stony Creek and Mudd Creek
- CC – Climate change option for a levee along Sara/ Day Street.

Property modification measures considered and recommended for the floodplain include:

- P1 – Planning controls – LEP update
- P2 – Building and development controls
- P8 – Flood proofing guidelines

Emergency response modification measures proposed for the floodplain include:

- EM1 – Information transfer to SES
- EM2 – Preparation and adoption of SES local flood plan
- EM3 – Flood warning system
- EM4 – Community flood awareness program
- EM5 – Flood depth markers

Data collection strategies proposed for the floodplain include:

- DC1 – Data collection following a flood event

The above listed flood, emergency and property modification measures ranked highly using a multi-criteria matrix assessment and have been selected for inclusion in the Draft Floodplain Risk Management Plan.

Those options selected for inclusion in the Draft Plan are based upon both their likely benefit and the funding available from Council and the State Government.

Based on the options recommended above, the cost of implementing the Plan would be an estimated capital cost of approximately \$3,495,000 and an annual recurrent cost of approximately \$32,200.

The draft Report was placed on public exhibition in September 2011 for comment by the public and stakeholders. This final Floodplain Risk Management Study document incorporates the one submission received during the exhibition period.

The final stages are the adoption and implementation of the actions in the Floodplain Risk Management Plan.

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## Glossary

<b>Annual Exceedence Probability (AEP)</b>	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1% AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large.
<b>Australian Height Datum (AHD)</b>	A common national surface level datum approximately corresponding to mean sea level.
<b>Cadastre, cadastral base</b>	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
<b>Catchment</b>	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
<b>Creek Rehabilitation</b>	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
<b>Design Flood</b>	A significant event to be considered in the design process; various works within the floodplain may have different design events: some roads may be designed to be overtopped in annual flood event.
<b>Development</b>	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
<b>Discharge</b>	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
<b>Flash flooding</b>	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain that causes it.
<b>Flood</b>	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river or drainage system.
<b>Flood fringe</b>	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
<b>Flood hazard</b>	Potential risk to life and limb caused by flooding.

<b>Flood-prone land</b>	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.
<b>Floodplain</b>	Area of a river valley adjacent to the river channel, which is subject to inundation by the probable maximum flood event.
<b>Floodplain management measures</b>	The full range of techniques available to floodplain managers.
<b>Floodplain management options</b>	The measures which might be feasible for the management of a particular area.
<b>Flood planning area</b>	The area of land below the flood planning level and thus subject to flood related development controls.
<b>Flood planning levels</b>	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the “Standard flood event” of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
<b>Flood storages</b>	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
<b>Floodway areas</b>	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.

<b>Geographical information systems (GIS)</b>	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
<b>High hazard</b>	Possible danger to life and limb; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.
<b>Hydraulics</b>	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
<b>Hydrograph</b>	A graph that shows how the discharge changes with time at any particular location.
<b>Hydrology</b>	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
<b>Integrated survey grid (ISG)</b>	ISG is a global co-ordinate system based on a Transverse Mercator Projection. The globe is divided into a number of zones, with the true origin at the intersection of the Central Meridian and the Equator.
<b>Low hazard</b>	Should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
<b>Mainstream flooding</b>	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
<b>Management plan</b>	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
<b>Mathematical/computer models</b>	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.

<b>NPER</b>	National Professional Engineers Register. Maintained by the Institution of Engineers, Australia.
<b>Peak discharge</b>	The maximum discharge occurring during a flood event.
<b>Probable maximum flood (PMF)</b>	The flood calculated to be the maximum that is likely to occur.
<b>Probability</b>	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedence Probability.
<b>Risk</b>	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
<b>Runoff</b>	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
<b>Stage</b>	Equivalent to 'water level'. Both are measured with reference to a specified datum.
<b>Stage hydrograph</b>	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.
<b>Stormwater flooding</b>	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
<b>Topography</b>	A surface which defines the ground level of a chosen area.

Terminology in this Glossary has been derived or adapted from the NSW Government *Floodplain Development Manual*, 2005, where available.

## Abbreviations

<b>AAD</b>	Average Annual Damage
<b>AEP</b>	Annual Exceedence Probability
<b>AHD</b>	Australian Height Datum
<b>ARI</b>	Average Recurrence Interval
<b>AWE</b>	Average Weekly Earnings
<b>BoM</b>	Bureau of Meteorology
<b>CPI</b>	Consumer Price Index
<b>DCP</b>	Development Control Plan
<b>DECC</b>	Department of Environment and Climate Change (formerly the Department of Environment and Conservation, now Office of Environment and Heritage)
<b>DNR</b>	Department of Natural Resources
<b>FPL</b>	Flood Planning Level
<b>FRMC</b>	Floodplain Risk Management Committee
<b>FRMP</b>	Floodplain Risk Management Plan
<b>FRMS</b>	Floodplain Risk Management Study
<b>GIS</b>	Geographic Information System
<b>GSDM</b>	Generalised Short Duration Method
<b>ha</b>	hectare
<b>IEAust</b>	Institution of Engineers, Australia
<b>IFD</b>	Intensity Frequency Duration
<b>km</b>	kilometres
<b>km<sup>2</sup></b>	Square kilometres
<b>LEP</b>	Local Environment Plan
<b>LGA</b>	Local Government Area
<b>m</b>	metre
<b>m<sup>2</sup></b>	Square metres

<b>m<sup>3</sup></b>	Cubic metres
<b>mAHD</b>	Metres to Australian Height Datum
<b>MHL</b>	Manly Hydraulics Laboratory
<b>MHWL</b>	Mean High Water Level
<b>mm</b>	millimetre
<b>m/s</b>	metres per second
<b>MSL</b>	Mean Sea Level
<b>NSW</b>	New South Wales
<b>OEH</b>	Office of Environment and Heritage (formerly DECC)
<b>PMF</b>	Probable Maximum Flood
<b>PMP</b>	Probable Maximum Precipitation
<b>RAFTS</b>	RAFTS proprietary software package
<b>RTA</b>	Roads and Traffic Authority
<b>SEPP</b>	State Environmental Planning Policy
<b>SES</b>	State Emergency Service

## 1 Introduction

A Floodplain Risk Management Study (FRMS) and Floodplain Risk Management Plan (FRMP) for the Stony Creek catchment has been prepared by Cardno Lawson Treloar for Lake Macquarie City Council. The Study identifies and examines options for the management of flooding within the Stony Creek catchment floodplain. This Plan takes the recommendations from the Study and incorporates them into a plan of implementation. Both studies have been prepared in accordance with the NSW Government *Floodplain Development Manual* (2005).

A locality plan is included as **Figure 1.1**. The outline of the study area is defined for the purposes of this study as the main developed areas in the lower catchment that are affected by mainstream flooding.

### 1.1 Study Context

The Floodplain Risk Management Study and Plan forms two stages of the Floodplain Management process, which consists of the following steps, as defined in the *Floodplain Development Manual* (NSW Government, 2005):

1. Formation of a Floodplain Management Committee;
2. Data Collection;
3. Flood Study;
- 4. Floodplain Risk Management Study;**
- 5. Floodplain Risk Management Plan;** and
6. Implementation of Floodplain Risk Management Plan.

This study was jointly funded by Council and the Office of Environment and Heritage (OEH). OEH also assists in the provision of specialist advice on flooding and related matters.

Previous flood studies include:

- Stony Creek Flood Study (Cardno Lawson Treloar, 2005)
- Lake Macquarie Floodplain Management Study (Webb McKeown & Associates, 2000)
- Lake Macquarie Floodplain Management Plan (Webb McKeown & Associates, 2001)

### 1.2 Study Objectives

The overall objective of the FRMS&P is to devise a strategy that addresses the existing, future and continuing flooding issues in the Stony Creek catchment in accordance with the NSW Government's Flood Policy, as detailed in the NSW *Floodplain Development Manual* (2005).

Objectives of the Stony Creek Floodplain Risk Management Study and Plan are to:

- Ensure that the most up-to-date information is available on flood behaviour within the study area for the full range of flood events; including flood flows, velocities, levels, depths, flood hazard extents, rates of rise of floodwaters and the locations of floodways and flood storage areas. The Stony Creek Flood Study (Cardno Lawson Treloar, 2005)

provides details for the 5 year ARI, 10 year ARI, 20 year ARI, 50 year ARI, 100 year ARI, 200 year ARI and the Probable Maximum Flood (PMF) events.

- Review Council's existing environmental planning policies and instruments, including Council's long term planning strategies for the study area.
- Identify works, measures and restrictions aimed at reducing the social, environmental and economic impacts of flooding and the losses caused by flooding on development and the community, both existing and future, over the full range of potential flood events. Innovative solutions for the management of the flood hazards within the study area are being sought along with effective community consultation and participation throughout the undertaking of the study.
- Assess the effectiveness of these works and measures for reducing the effects of flooding on the community and development, both existing and future.
- Consider whether the proposed works and measures could produce adverse effects (environmental, social, economic, or flooding) in the floodplain and, if so, whether they can be minimized.
- Examine and recommend measures to improve community flood awareness and emergency response measures in the context of the NSW State Emergency Service's disaster planning requirements.

### 1.3 Study Methodology

The Floodplain Risk Management Plan report details the recommended actions to be implemented based on the assessment detailed in the Floodplain Risk Management Study report.

## **2 Existing Flood Behaviour**

The following provides an overview of the existing flooding behaviour within the Stony Creek catchment. A more detailed overview can be found in the Floodplain Risk Management Study.

### **2.1 Background**

The Stony Creek catchment lies within the Lake Macquarie catchment situated to the north-west side of the Lake. The catchment headwaters are located in the west, incorporating the Awaba State Forest. The catchment outlet is at Fennell Bay within Lake Macquarie. There are several large tributaries of Stony Creek and the catchment has an approximate area of 46.4km<sup>2</sup>.

The land use in the upper reaches of the catchment is rural or bushland. The F3 Freeway passes through the upper reaches of the catchment with a large bridge conveying flow on Palmers Creek and culverts conveying flow for all the minor creek crossings. Other major controls in the upper catchment are the Coal Haul Road and the Great Northern Railway.

In the lower reaches, the catchment is developed with low to medium density housing and some industrial and commercial areas. Mudd Creek is situated in the urban area downstream of the Sewage Treatment Works and flows parallel to Stony Creek discharging into Edmunds Bay.

### **2.2 Revision of Flood Study**

A detailed flood study of Stony Creek was completed by Cardno Lawson Treloar in 2005. The flood study presented the flood extents and damage costs for a range of recurrence intervals based on hydrologic and hydraulic modelling completed. The SOBEK computer model used to assess flood behaviour for the flood study was reviewed and adopted for application in the Floodplain Risk Management Study.

Information from the Flood Study was reviewed and applied to assess potential flood management measures as detailed in the Floodplain Risk Management Study report.

### **2.3 Flood Behaviour**

Peak water levels modelled in the study area are shown in the attached figures from the Floodplain Risk Management Study report:

- Figure 5.1 – PMF Peak Flood Levels
- Figure 5.3 – 100y ARI Peak Flood Levels
- Figure 5.5 – 20y ARI Peak Flood Levels

## 2.4 Damage Analysis

A flood damage assessment for the existing catchment conditions and several flood management options has been completed and detailed in the Stony Creek Floodplain Risk Management Study.

**Table 2.1** shows the results of the flood damage assessment for the existing conditions. Based on the analysis described in the Floodplain Risk Management Study, the average annual damage for the floodplain under existing conditions is approximately \$247,000.

**Table 2.1: Flood Damage Assessment Summary**

Event/Property Type	Number of Properties with overfloor flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Number of Properties with overground flooding	Total Damage (\$February 2009) *
<b>PMF</b>					
Residential	247	1.18	2.56	262	\$13,643,936
Commercial	11	1.73	2.66	12	\$ 2,323,959
Industrial	37	1.98	2.81	37	\$ 6,672,604
PMF Total	295			311	\$22,640,498
<b>200 year ARI</b>					
Residential	66	0.68	0.78	177	\$ 3,539,542
Commercial	3	0.51	0.40	8	\$ 106,218
Industrial	18	0.85	0.65	30	\$ 744,216
200 Year ARI Total	87			215	\$ 4,389,976
<b>100 year ARI</b>					
Residential	41	0.19	0.66	165	\$ 2,611,634
Commercial	3	0.26	0.30	6	\$ 76,243
Industrial	13	0.15	0.67	26	\$ 397,323
100 Year ARI Total	57			197	\$ 3,085,200
<b>50 year ARI</b>					
Residential	20	0.18	0.52	147	\$ 1,740,389
Commercial	3	0.15	0.20	6	\$ 31,359
Industrial	6	0.12	0.42	21	\$ 83,624
50 Year ARI Total	29			174	\$ 1,855,372
<b>20 year ARI</b>					
Residential	7	0.21	0.37	98	\$ 927,695
Commercial	2	0.08	0.10	5	\$ 19,267
Industrial	1	0.09	0.09	3	\$ 4,677
20 Year ARI Total	10			106	\$ 951,638

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Event/Property Type	Number of Properties with overfloor flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Number of Properties with overground flooding	Total Damage (\$February 2009) *
<b>10 year ARI</b>					
Residential	3	0.12	0.16	59	\$ 494,738
Commercial	0	-	-	2	\$ -
Industrial	1	0.04	0.04	2	\$ 2,907
10 Year ARI Total	4			63	\$ 497,645
<b>5 year ARI</b>					
Residential	0	-	-	25	\$ 164,108
Commercial	0	-	-	1	\$ -
Industrial	0	-	-	1	\$ -
5 Year ARI Total	0			27	\$ 164,108

\*values are expressed to the nearest dollar, but this is not indicative of the accuracy of the estimates

### 3 Floodplain Risk Management Options

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. As a result, there are three broad types of measures for the management of flooding that have been addressed:

- Flood Modification Measures (for the existing risk)
- Property Modification Measures (for the future risk)
- Emergency Response Modification Measures (for the residual risk).

A range of options were considered as a part of the floodplain risk management plan. These are discussed in detail in the Floodplain Risk Management Study, and are summarised below.

#### 3.1 Flood Modification Measures

Details of the measures are listed in **Table 3.1** and summarised in this Section, with a more detailed description in the Floodplain Risk Management Study **Section 9**.

**Table 3.1: Flood Modification Measures**

Option	Location	Option Description
<b>Detention Basins</b>		
FM1.1	Upstream of railway line – 8 sites	Eight detention basins distributed across upstream catchment
FM1.2	Upstream of railway line – 1 site	One detention basin just upstream of the railway line
<b>Carleton Drain</b>		
FM 2.1	Carleton Street	Additional culvert
FM 2.2	Carleton Street	Augmentation of existing culverts and additional culvert
FM 2.3	Carleton Street and Awaba Road	Augmentation of existing culverts at Carleton Street and Awaba Road. Additional culvert at Carleton Street
<b>Levee Banks</b>		
FM 3.1	Toronto industrial area	Construct levee bank from Burleigh St to May St
FM 3.2	Blundell Parade, Farrell Ave, and Galbraith Ave	Construct levee bank along Stony Creek
FM 3.3	Fennell Cres. Between Mudd Creek and Stony Creek	

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Option	Location	Option Description
FM 3.4	Adam St and Fennell Cres. (north of Mudd Creek)	
FM 3.5	Lake St and Venetia Ave	Construct levee bank to Edmunds Bay, Mudd Creek and Stony Creek
FM 3.6	Sara St and Day Street	Construct levee bank to Stony Creek
<b>Railway Parade</b>		
FM 4.1	Railway Parade – Mudd Creek	Augment culvert crossing of Mudd Creek
FM 4.2	Railway Parade – Mudd Creek	Augment culvert crossing of Mudd Creek. Remove railway line and crossings downstream of Railway Parade
FM 4.3	Railway Parade – Stony Creek	Augment culvert crossing of Stony Creek
FM 4.4	Railway Parade – Stony Creek	Augment culvert crossing of Stony Creek. Remove railway line and crossings downstream of Railway Parade
FM 4.5	Railway Parade – Stony Creek and Mudd Creek	Augment culvert crossings of Mudd Creek and Stony Creek
FM 4.6	Railway Parade – Stony Creek and Mudd Creek	Augment culvert crossings of Mudd Creek and Stony Creek. Remove railway line and crossings downstream of Railway Parade
FM 4.7	Railway Parade – Stony Creek and Mudd Creek	Remove railway line and crossings downstream of Railway Parade
FM 4.8	Railway Parade – Mudd Creek	Raise road crossing of creek
FM 4.9	Railway Parade – Stony Creek and Mudd Creek	Augment flow connection between Mudd Creek and Stony Creek
<b>Rainwater Tanks</b>		
FM 5.1	Catchment wide	Rainwater tanks installed to all properties
<b>Infiltration Basins &amp; Trenches</b>		
FM 6.1	Across catchment	Construct infiltration basins and trenches to locations across catchment
<b>Lake Macquarie Measures</b>		
FM 7.1	Swansea Channel	Dredging works at channel entrances and augmentation of Swansea Bridge
FM 7.2	Lake Macquarie Foreshore Levees	Construct levees around Lake Macquarie foreshore

Option	Location	Option Description
<b>Flood Flowpath Improvement</b>		
FM8.1	Catchment Wide	Clearing debris from flowpaths and dredging of creeklines.

### 3.2 Property Modification Options

As outlined in the Floodplain Risk Management Study, there are a number of opportunities for the use of planning legislation, plans, policies or guidelines for the management of flood liable areas of the catchment.

**Table 3. 2: Property Modification Options**

Option	Name	Option Description
P1	LEP Update	Only relatively minor changes required, most likely associated with updating to the standard template.
P2	Building & Development Controls	A number of specific controls for Stony Creek are recommended for inclusion in the DCP.
P3	House Raising	This reduces the risk of overfloor flooding by raising the building itself. However, there are a number of constraints on this which limit its applicability.
P4	House Rebuilding	An alternative to house raising where the subsidy from house raising is utilised for re-construction instead.
P5	Voluntary Purchase	An alternative to house raising is to offer voluntary purchase of properties. However, this should be considered only after all other options are exhausted.
P6	Land Swap	An alternative to voluntary purchase whereby Council swaps a parcel of land in a non-flood prone area for the flood prone land.
P7	Council Redevelopment	An alternative to voluntary purchase where Council purchases the land and re-develops in a flood compatible manner.
P8	Flood Proofing	Incorporating structural and other procedures in order to reduce to eliminate the risk to life and property. This can also include temporary flood protection measures such as flood barriers.

### 3.3 Emergency Response Modification Options

Option	Name	Option Description
EM1	Information Transfer to SES	Transfer of findings from flood study and floodplain risk management study and plan to the SES.
EM2	Update of Local Flood Plan	Update Local Flood Plan in light of the findings of the Floodplain Risk Management Study (refer Section 7 of the Floodplain Risk Management Study).
EM3	Flood Warning System	The critical durations and response times for flooding in the lower reaches of the catchment may mean the implementation of a flood warning system is feasible. The flow behaviour was examined for the potential application of a flood warning system in the Floodplain Risk Management Study.
EM4	Public Awareness and Education	Improvement of flood awareness in the community assists in reducing the overall flood risk. An ongoing commitment to an awareness program is required to ensure flood awareness is maintained.
EM5	Flood Warning Signs at Critical Locations	Flood warning signs placed at public locations where high hazard flooding is experienced.
EM6	Fennell Crescent Evacuation Route	This option would raise the Fennell Crescent crossing of Mudd Creek to allow residents to evacuate in this direction during a flood event. This option was not considered viable in the Floodplain Risk Management Study.
EM7	Lake Street/ Venetia Avenue	Raising of these roads to provide a flood-free evacuation route. This option was not considered viable in the Floodplain Risk Management Study.

#### DC1 - Data Collection Strategies

This would involve the preparation of a flood data collection form and use of this form following a flood event. This would allow for more information to be gathered concerning the nature of flooding within the catchment, building on the knowledge from the Flood Study.

## **4 Findings of Floodplain Risk Management Study**

Both the Triple Bottom Line matrix (**Appendix A**) and the economic cost benefit analysis (**FRMSP Table 10.3**) were used in the development of this Plan. The economic analysis, while limited to only the modelled options, provides a more detailed analysis of the financial cost benefit. Given the nature of the scoring system in the multi-criteria analysis, this detail reduces its significance. However, the Triple Bottom Line matrix provides a more thorough view of all the options. Therefore, both tables (**Appendix A** and **FRMSP Table 10.3**) need to be viewed together, where possible, in order for a comprehensive analysis of the options.

Updates to both will be undertaken following the review process and the community consultation. These updates may affect the ranking of the options, which will affect the outcomes of this Plan.

The plan consists of a mixture of:

- Property modification options
- Emergency response modification options
- Flood modification options.

Triple Bottom Line and Economic Benefit/ Cost Ratio analysis provide direction in the selection of various options. However, the final selection of options needs to consider other factors relevant to the floodplain and wider community. For the purpose of selecting a list of options for the Plan, the following criteria have been adopted:

- Overall ranking in the Triple Bottom Line matrix and Benefit/ Cost ratio where available
- Benefits to the wider community rather than localised benefits

The flood management options recommended in the plan are provided in **Section 6**.

## 5 Climate Change

Climate Change can affect the Stony Creek catchment through Sea Level Rise as well as changes to rainfall intensities. A number of alternative scenarios were assessed and are detailed in **Appendix G** of the Floodplain Risk Management Study.

A number of options were also considered to address the estimated impacts of climate change on the floodplain. Assessment of the measures is detailed in **Appendix G** of the Floodplain Risk Management Study.

The economic viability of the option is dependent on the time, as the potential impact of climate change will continue to increase over time. Therefore, an option which is not viable now may become viable at some stage in the future. The economic analysis took this into account, by investigating both the benefit cost ratio now as well as the year in which the benefit cost ratio is expected to equal 1 (i.e. become economically viable). The results of this analysis are presented in **Table 5.2**.

Both the Lake Street/ Venetia Levee and the Sara/ Day Street Levee were either economically viable or viable in the very near future. However, as noted, the Lake Street/ Venetia Levee is likely to have a number of additional social and environmental issues which may result in significant challenges. As such, it is unlikely that this particular option will be viable in the immediate future and should be considered in subsequent reviews of the Floodplain Risk Management Plan or in reviews to the climate change estimates.

The Sara/ Day Street Levee is economically viable now, and does not have the same level of social or environmental constraints. As such, this option is recommended for additional investigation and implementation.

The other options addressed below are recommended to be included in subsequent reviews of the Floodplain Risk Management Plan or climate change estimates, as none of these are viable within the next 10 years.

**Table 5.1: Summary of Measures for Climate Change Impacts**

		Industrial Levee	Adam St Levee	Fennell Cres Levee	Sara/ Day St Levee	Lake/ Venetia Levee
Benefit Cost Ratios	Upfront Protection	0.63	0.62	0.48	1.75	0.87
	Retrofit in Future	0.69	0.63	0.48	2.08	0.94
Year to Start Deferred Works (B/C=1)		2020	2032	2054	N/A	2012

## 6 Implementation Program

The implementation program essentially forms the action list for this Plan. This action list is shown in **Table 6.1**.

The benefit of following this sequence is that gradual improvement of the floodplain occurs, as the funds become available for implementation of these options.

Further steps in the floodplain management process from this point onwards are:

1. Floodplain Management Committee to consider and adopt recommendations of this Plan
2. Council considers the Floodplain Management Committee's recommendations,
3. Council adopt the Plan and submit an application for funding assistance to OEH and other agencies as appropriate,
4. As funds become available from OEH, other state government agencies and/or Council's own resources, implement the measures in accordance with the established priorities.

This plan should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding and reviews of the Council planning. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

There are a few important points to note in regards to the plan:

- Option FM1.2 – the construction of the detention basin upstream of the railway – has widespread benefits for the Stony Creek Floodplain. It may therefore negate the need for Option FM3.1 and FM4.7.
- If Option FM3.1 and FM4.7 are not required, then the capital outlay of the plan would be equal to \$1,862,000.
- Option FM4.7 requires the removal of the disused railway line over Stony Creek and Mudd Creek. This would require approvals from the various stakeholders.
- The options selected for the plan are based on the ranking in the multi-criteria analysis and the economic cost benefit analysis. The options selected represent a capital outlay of approximately \$3,495,000, which is in the order of the present value of the annual average damages in the catchment. Note that this present value would increase if the effects of climate change were incorporated.

### 6.1 Key Stakeholders

As a part of the implementation of the Plan and the detailed design phase of some of the options, liaison should be undertaken with key stakeholders. These key stakeholders should include, but are not limited to:

- Hunter Water - particularly with regards to any impacts on their assets within the catchment.
- SES - particularly in regards to Option EM1, EM2, EM3, EM4 and EM5
- OEH - as it is likely that funding would be sourced from OEH for a number of the options, they should be consulted as a part of the design process.

- State Rail Authority / Rail Corp – FM1.2 and FM4.7 would require close liaison with the organisation to ensure an optimal design and minimal impact on the transport corridor.
- RTA - to be consulted regarding options that impact on any RTA roads in the study area.
- Private Residents – in particular, those residents to be affected by the proposed works.

## Stony Creek Floodplain Risk Management Plan

Prepared for Lake Macquarie City Council

**Table 6.1: Floodplain Risk Management Measures Recommended for Inclusion in the Stony Creek Risk Management Plan**

Option ID	Location	Description	Estimated Capital Cost	Estimated Recurring Cost	Funding Sources / Responsibility	Priority for Implementation
EM1	Lake Macquarie LGA	Information Transfer to SES	\$2,000	\$0	Council/ SES	High
DC1	Stony Creek Floodplain	Data collection following a flood event	\$5,000	\$2,000	Council	High
P1	Lake Macquarie LGA	Planning Controls - LEP Update	\$10,000	\$1,000	Council	High
P2	Lake Macquarie LGA	Building and Development Controls	\$10,000	\$1,000	Council/ SES	High
P8	Stony Creek Floodplain	Flood proofing guidelines	\$10,000	\$1,000	Council/ SES	High
EM4	Stony Creek Floodplain	Community Flood Awareness	\$10,000	\$2,000	Council	High
EM5	Selected locations throughout the floodplain	Depth Markers at Street Crossings	\$6,000	\$200	Council/ SES	Medium
EM3	Stony Creek Floodplain	Flood Warning System	\$50,000	\$10,000	Council/ OEH	Medium
EM2	Lake Macquarie LGA	Preparation and Adoption of SES Local Flood Plan	\$30,000	\$2,000	Council/ OEH	Medium
FM1.2	Upstream of railway line – 1 site	One detention basin just upstream of the railway line	\$1,296,000	\$5,000	Council/ OEH	Low
FM 3.1	Toronto industrial area	Construct levee bank from Burleigh St to May St	\$639,000	\$5,000	Council/ OEH	Low
FM 4.7	Railway Parade – Stony Creek and Mudd Creek	Remove railway line and crossings downstream of Railway Parade	\$1,001,000	\$0	Council/ OEH	Low
CC	Sara/ Day Street Levee	Levee to protect this particular area from the impacts of climate change	\$433,000	\$5000	Council/ OEH	Low
<b>Total Cost of Implementing the Plan</b>			<b>\$3,495,000</b>	<b>\$32,200</b>		

## **7 Recommendations and Conclusions**

This report presents the findings of the Floodplain Risk Management Plan for Stony Creek. The investigations and consultation undertaken as part of the Floodplain Risk Management Study identified a number of issues for the floodplain. Based on these issues, a series of floodplain management measures were developed and have been recommended in this Floodplain Risk Management Plan (**Section 5**).

The assessment of management options provided in the Floodplain Risk Management Study facilitates the identification of the most beneficial options (in terms of hydraulics, economics, environmental and social issues). This assessment was based on a primarily technical review and consultation with the community working group. Further community and stakeholder feedback will be incorporated into the final report. This could lead to changes in the proposed options and their ranking.

Further public consultation is to be undertaken during the exhibition of this Study and Plan. Additional consultation and review will lead to the refinement of this Study and the final recommended floodplain risk management options for implementation.

## 8 Qualifications

This report has been prepared by Cardno Lawson Treloar for Lake Macquarie City Council and as such should not be used by a third party without approval.

The investigation and modelling procedures adopted for this study follow industry standards and considerable care has been applied to the preparation of the results. However, model set-up depends on the quality of data available. The flow regime and the flow control structures are complicated and can only be represented by schematised model layouts. Hence there will be a level of uncertainty in the results and this should be borne in mind in their application.

The results of the study are based on the following assumptions / conditions:

- Legislation and planning policies are correct at the time of report issue but are subject to change,
- Cost estimates provided for options in this report are preliminary only and more detailed cost estimates should be prepared during the detailed design phase, and
- Data and modelling qualifications noted in the Stony Creek Flood Study (2005).

Study results should not be used for purposes other than those for which they were prepared.

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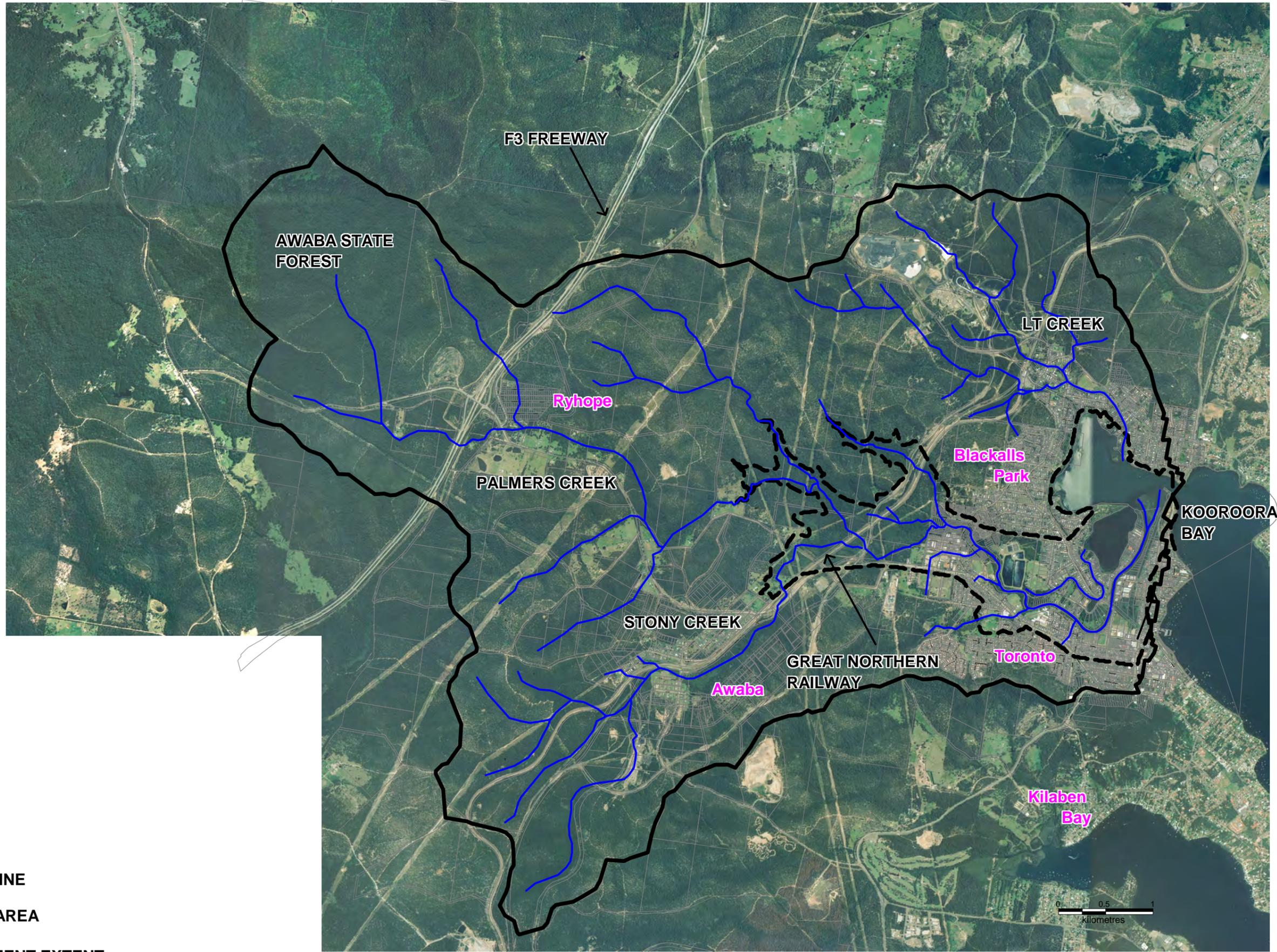
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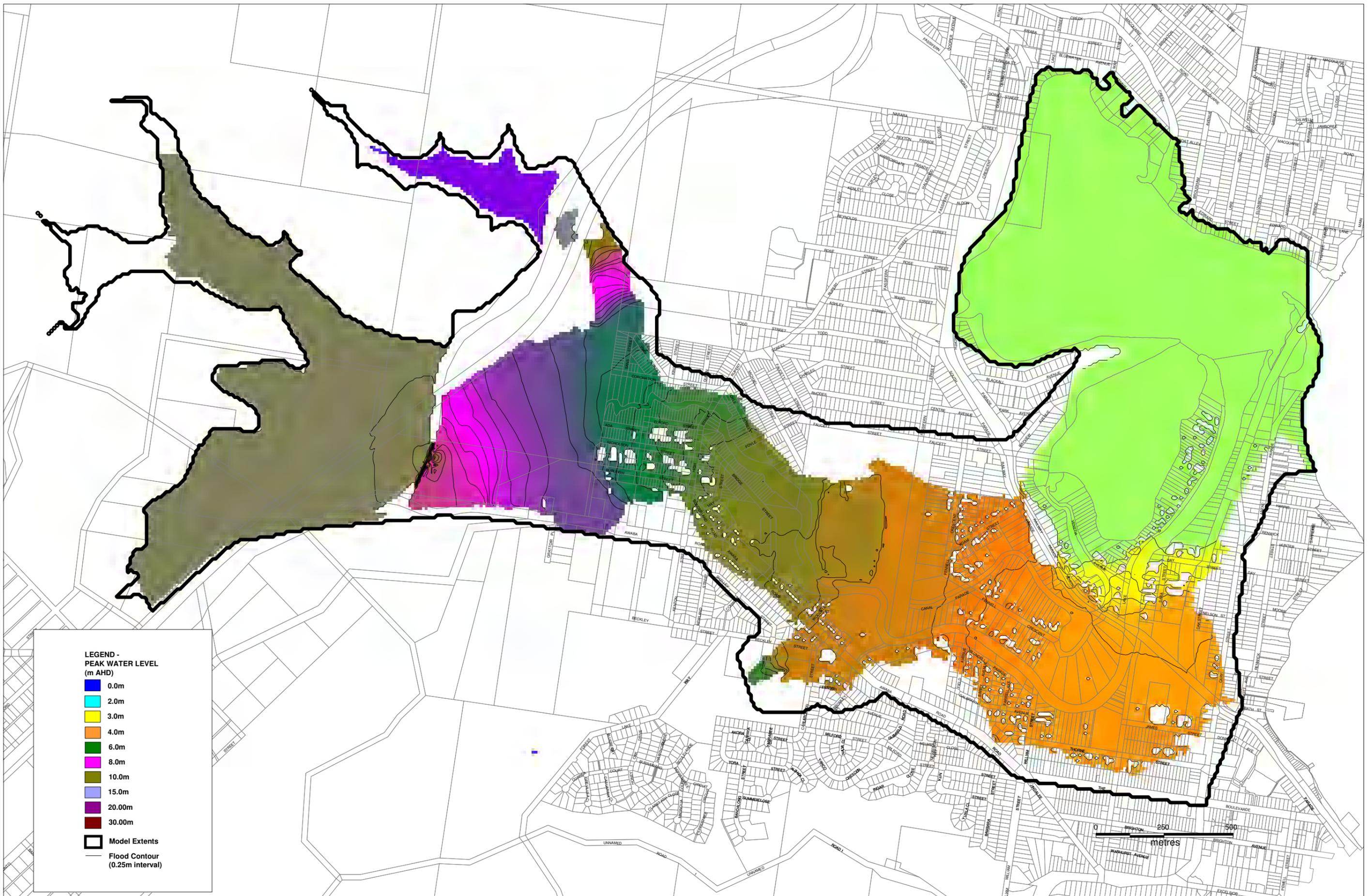
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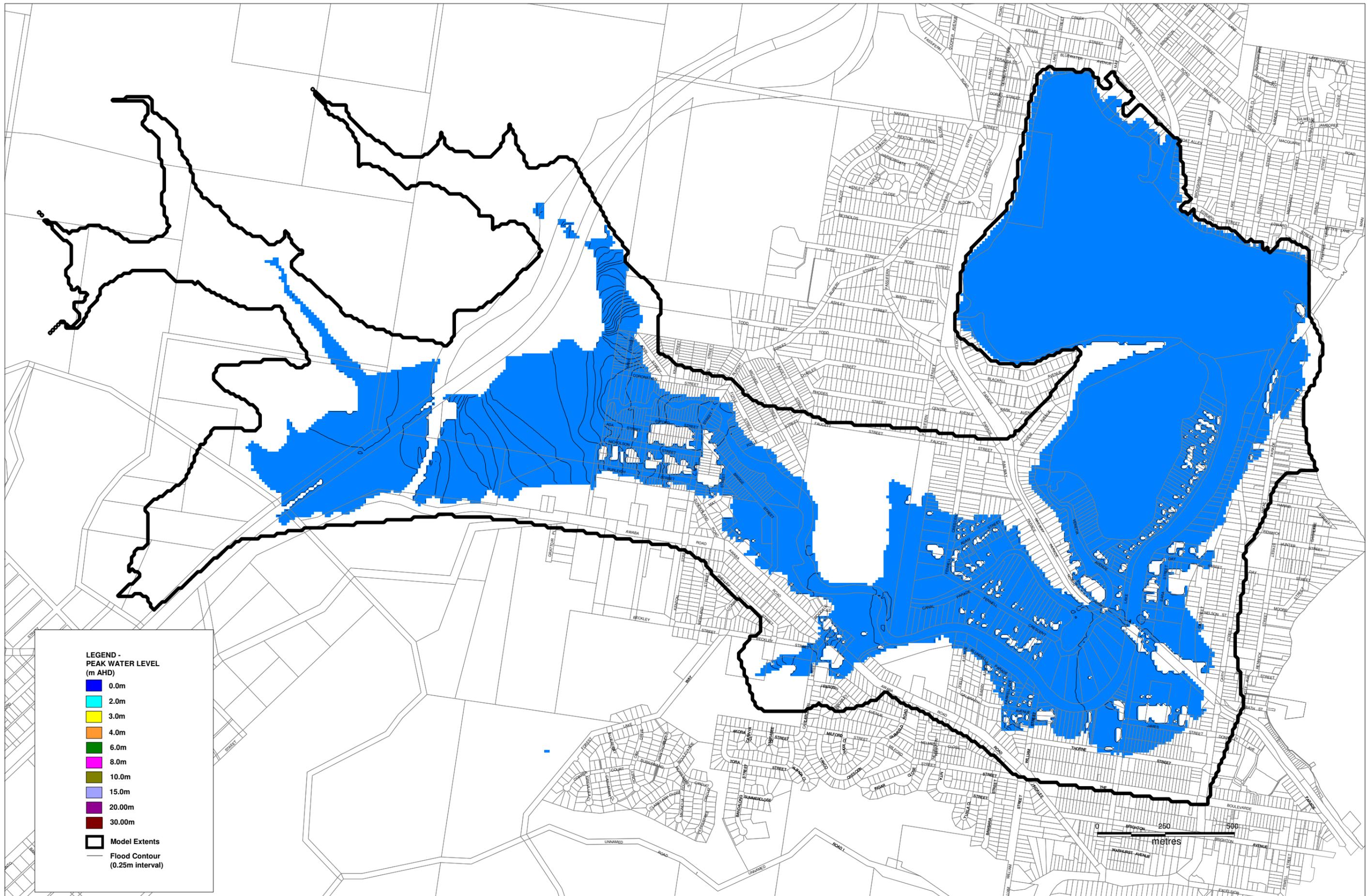
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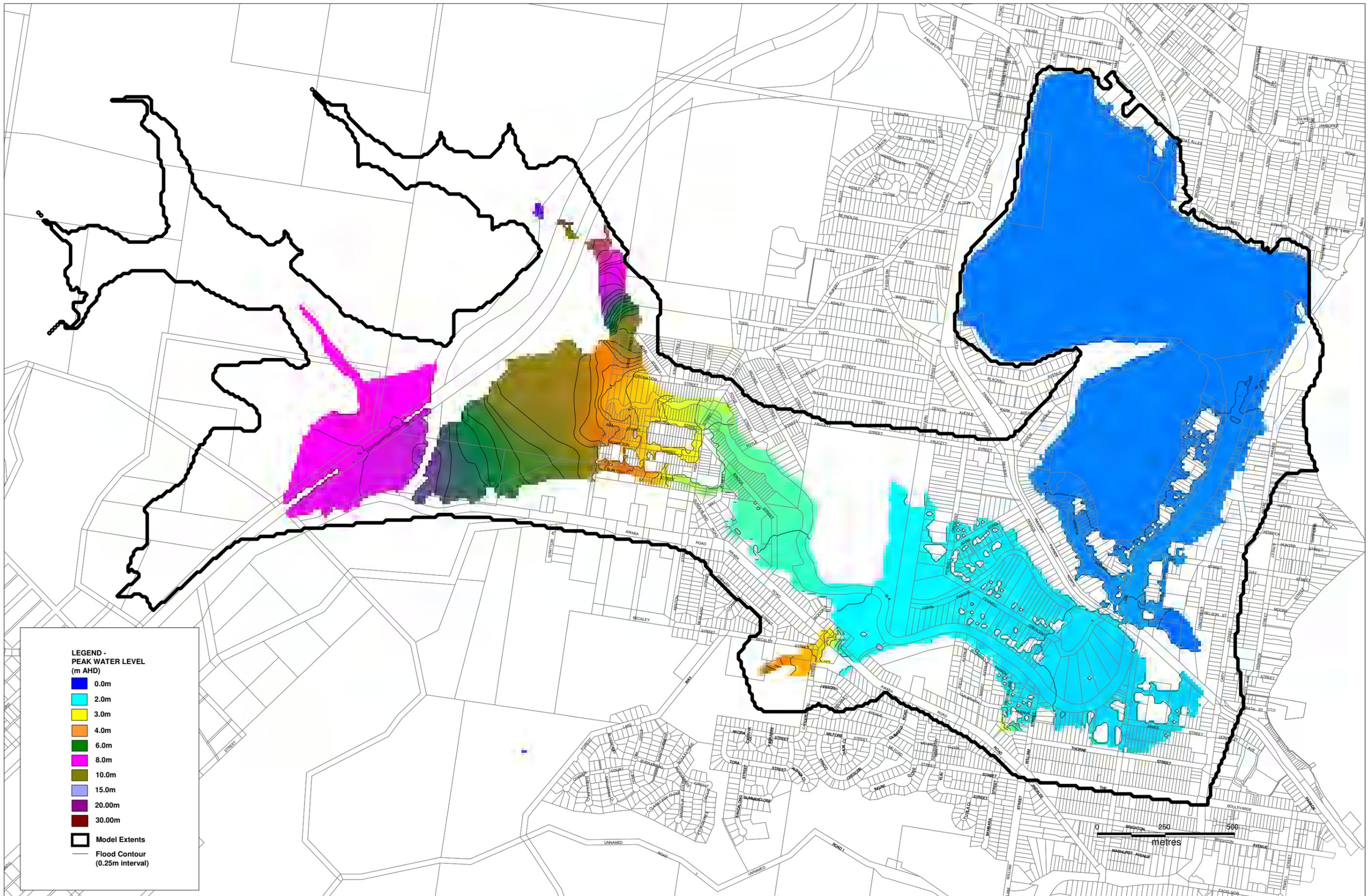
# Figures



- CREEKLINE
- STUDY AREA
- CATCHMENT EXTENT







**Appendix A**

# **Multi-Criteria Matrix Assessment**

## Multi-Criteria Matrix

ID	Category of Measure	Location	Description	Estimate of Capital Cost	Estimate of Recurrent Cost	Net Present Value (7%, 50 years)	Reduction in AAD	% reduction in c.f. to base case	NPV of Reduction in AAD	Benefit - Cost Ratio	Score on Benefit Cost Ratio	Capital and Operating Costs	Reduction in Risk to Property	Economic Score	Reduction in Risk to Life	Reduction in Social Disruption	Community Criteria	Council Support	Compatible with Policies and Plans	Social Score	Water Quality and Flow	Fauna & Flora	Environmental Score	TOTAL SCORE	RANK on TOTAL SCORE
P1	Property Modification	Lake Macquarie LGA	Planning Controls - LEP Update	\$3,000	\$1,000	\$15,409	NC	N/A	N/A	N/A	2	2	2	2.0	2	1	1	2	2	1.6	0	0	0.0	5.6	1
P2	Property Modification	Lake Macquarie LGA	Building and Development Controls	\$10,000	\$1,000	\$22,409	NC	N/A	N/A	N/A	2	2	2	2.0	2	1	1	2	2	1.6	0	0	0.0	5.6	1
P3	Property Modification	Selected locations throughout the floodplain	House raising	\$320,000	\$0	\$320,000	\$8,000	3.2%	\$99,272	0.31	-2	0	1	-0.8	1	1	0	0	2	0.8	0	0	0.0	-0.7	20
P4	Property Modification	Selected locations throughout the floodplain	House Rebuilding	An option for properties eligible for house raising																					
P5	Property Modification	Selected locations throughout the floodplain	Voluntary purchase	\$1,200,000	\$0	\$1,200,000	\$16,000	6.5%	\$198,545	0.17	-2	-1	1	-1.0	2	1	0	0	2	1.0	0	0	0.0	-1.0	21
P6	Property Modification	Selected locations throughout the floodplain	Land swap	To be assessed for properties before voluntary purchase proceeds																					
P7	Property Modification	Selected locations throughout the floodplain	Acquisition & Council Redevelopment	\$2,000,000	\$0	\$2,000,000	\$16,000	6.5%	\$198,545	0.10	-2	-1	1	-1.0	2	1	0	0	2	1.0	0	0	0.0	-1.0	21
P8	Property Modification	Stony Creek Floodplain	Flood proofing guidelines	\$10,000	\$1,000	\$22,409	NC	N/A	N/A	N/A	2	2	2	2.0	0	1	1	2	2	1.2	0	0	0.0	5.2	3
EM1	Emergency Response Modification	Lake Macquarie LGA	Information Transfer to SES	\$2,000	\$0	\$2,000	NC	N/A	N/A	N/A	0	2	0	0.5	2	2	0	2	2	1.6	0	0	0.0	2.6	5
EM2	Emergency Response Modification	Lake Macquarie LGA	Preparation and Adoption of SES Local Flood Plan	\$30,000	\$2,000	\$54,818	NC	N/A	N/A	N/A	0	1	0	0.3	2	2	0	2	2	1.6	0	0	0.0	2.1	10
EM3	Emergency Response Modification	Stony Creek Floodplain	Flood Warning System	\$50,000	\$10,000	\$174,090	NC	N/A	N/A	N/A	0	1	1	0.5	2	2	1	1	2	1.6	0	0	0.0	2.6	5
EM4	Emergency Response Modification	Stony Creek Floodplain	Community Flood Awareness	\$10,000	\$2,000	\$34,818	NC	N/A	N/A	N/A	0	2	1	0.8	2	2	1	2	2	1.8	0	0	0.0	3.3	4
EM5	Emergency Response Modification	Selected locations throughout the floodplain	Depth Markers at Street Crossings	\$6,000	\$200	\$8,482	NC	N/A	N/A	N/A	0	2	0	0.5	2	2	0	1	2	1.4	0	0	0.0	2.4	7
EM6	Emergency Response Modification	Fennell Crescent	Fennell Crescent Evacuation Route	Not Viable, refer to report																					
EM7	Emergency Response Modification	Lake Street/ Venetia Avenue	Lake Street/ Venetia Avenue Evacuation Route	Not Viable, refer to report																					
FM1.1	Flood Modification	Upstream of railway line – 8 sites	Eight detention basins distributed across upstream catchment	\$4,000,000	\$15,000	\$4,186,136	NC	N/A	N/A	N/A	-1	-2	2	-0.5	2	2	-2	-2	-2	-0.4	0	-2	-1.0	-2.4	32
FM1.2	Flood Modification	Upstream of railway line – 1 site	One detention basin just upstream of the railway line	\$1,296,438	\$5,000	\$1,358,483	\$103,949	42.1%	\$1,289,904	0.95	1	-1	2	0.8	2	2	2	2	-1	1.4	0	-2	-1.0	1.9	11
FM 2.1	Flood Modification	Carleton Street	Additional culvert	\$350,000	\$5,000	\$412,045	NC	N/A	N/A	N/A	-2	0	1	-0.8	0	1	-1	0	2	0.4	0	0	0.0	-1.1	24
FM 2.2	Flood Modification	Carleton Street	Augmentation of existing culverts and additional culvert	\$500,000	\$5,000	\$562,045	NC	N/A	N/A	N/A	-2	-1	1	-1.0	0	1	-1	0	2	0.4	0	0	0.0	-1.6	27
FM 2.3	Flood Modification	Carleton Street and Awaba Road	Augmentation of existing culverts at Carleton Street and Awaba Road. Additional culvert at Carleton Street	\$1,327,898	\$5,000	\$1,389,943	\$4,199	1.7%	\$52,107	0.04	-2	-2	1	-1.3	0	1	-1	0	2	0.4	0	0	0.0	-2.1	31
FM 3.1	Flood Modification	Toronto industrial area	Construct levee bank from Burleigh St to May St	\$639,067	\$5,000	\$701,112	\$10,522	4.3%	\$130,567	0.19	1	-1	2	0.8	2	2	-2	2	2	1.2	0	-1	-0.5	2.2	8
FM 3.2	Flood Modification	Blundell Parade, Farrell Ave, and Galbraith Ave	Construct levee bank along Stony Creek	Not Viable, potential negative impacts																					
FM 3.3	Flood Modification	Fennell Cres. Between Mudd Creek and Stony Creek	Levee Bank	\$1,748,561	\$5,000	\$1,810,606	NC	N/A	N/A	N/A	-1	-1	2	-0.3	2	2	-2	-2	2	0.4	0	-1	-0.5	-0.6	19
FM 3.4	Flood Modification	Adam St and Fennell Cres. (north of Mudd Creek)	Levee Bank	\$1,165,707	\$5,000	\$1,227,753	\$35,800	14.5%	\$444,246	0.36	1	-1	2	0.8	2	2	-2	-2	2	0.4	0	-1	-0.5	1.4	13
FM 3.5	Flood Modification	Lake St and Venetia Ave	Construct levee bank to Edmunds Bay, Mudd Creek and Stony Creek	\$1,597,668	\$5,000	\$1,659,713	NC	N/A	N/A	N/A	-1	-1	2	-0.3	2	2	-2	-1	2	0.6	0	-1	-0.5	-0.4	18
FM 3.6	Flood Modification	Sara St and Day Street	Construct levee bank to Stony Creek	\$400,000	\$5,000	\$462,045	NC	N/A	N/A	N/A	0	0	2	0.5	1	1	-2	-1	2	0.2	0	-1	-0.5	0.7	14
FM 4.1	Flood Modification	Railway Parade – Mudd Creek	Augment culvert crossing of Mudd Creek	\$2,100,000	\$5,000	\$2,162,045	NC	N/A	N/A	N/A	-1	-2	2	-0.5	2	2	-1	-1	2	0.8	0	0	0.0	-0.2	17
FM 4.2	Flood Modification	Railway Parade – Mudd Creek	Augment culvert crossing of Mudd Creek. Remove railway line and crossings downstream of Railway Parade	\$2,290,059	\$5,000	\$2,352,104	\$40,047	16.2%	\$496,942	0.21	-1	-2	2	-0.5	2	2	-2	-1	-1	0.0	0	0	0.0	-1.0	21
FM 4.3	Flood Modification	Railway Parade – Stony Creek	Augment culvert crossing of Stony Creek	\$2,500,000	\$5,000	\$2,562,045	NC	N/A	N/A	N/A	-2	-2	2	-1.0	2	2	-1	-1	2	0.8	0	0	0.0	-1.2	25
FM 4.4	Flood Modification	Railway Parade – Stony Creek	Augment culvert crossing of Stony Creek. Remove railway line and crossings downstream of Railway Parade	\$2,700,000	\$5,000	\$2,762,045	NC	N/A	N/A	N/A	-2	-2	2	-1.0	2	2	-1	-1	-1	0.2	0	0	0.0	-1.8	28
FM 4.5	Flood Modification	Railway Parade – Stony Creek and Mudd Creek	Augment culvert crossings of Mudd Creek and Stony Creek	\$4,000,000	\$10,000	\$4,124,090	NC	N/A	N/A	N/A	-2	-2	2	-1.0	2	2	-1	-1	2	0.8	0	0	0.0	-1.2	25
FM 4.6	Flood Modification	Railway Parade – Stony Creek and Mudd Creek	Augment culvert crossings of Mudd Creek and Stony Creek. Remove railway line and crossings downstream of Railway Parade	\$4,388,699	\$10,000	\$4,512,789	\$64,087	2.5	\$795,253	0.18	-2	-2	2	-1.0	2	2	-2	-1	-1	0.0	0	0	0.0	-2.0	30
FM 4.7	Flood Modification	Railway Parade – Remove Downstream Railway Line and Crossings	Remove railway line and crossings downstream of Railway Parade	\$1,001,000	\$0	\$1,001,000	\$36,185	1.4	\$449,016	0.45	1	-1	2	0.8	1	2	-2	0	-1	0.0	0	0	0.0	1.5	12
FM 4.8	Flood Modification	Railway Parade – Mudd Creek	Raise road crossing of creek	Not Viable, refer to report																					
FM 4.9	Flood Modification	Railway Parade – Stony Creek and Mudd Creek	Augment flow connection between Mudd Creek and Stony Creek	\$300,000	\$2,000	\$324,818	NC	N/A	N/A	N/A	-2	0	0	-1.0	0	0	0	1	2	0.6	0	-1	-0.5	-1.9	29
FM 5.1	Flood Modification	Catchment wide	Rainwater Tanks	\$0	\$50,000	\$620,452	NC	N/A	N/A	N/A	-2	-1	0	-1.3	0	0	2	2	2	1.2	2	1	1.5	0.2	15
FM 6.1	Flood Modification	Catchment wide	Infiltration Basins & Trenches	\$0	\$50,000	\$620,452	NC	N/A	N/A	N/A	-2	-1	0	-1.3	0	0	2	2	2	1.2	2	1	1.5	0.2	15
FM 7.1	Flood Modification	Lake Macquarie measures	Swansea Channel	Lake Macquarie Wide Option - Assessed as part of Lake Macquarie Floodplain Management Study																					
FM 7.2	Flood Modification	Lake Macquarie measures	Levees	Lake Macquarie Wide Option - Assessed as part of Lake Macquarie Floodplain Management Study																					
DC1	Data Collection Strategies	Stony Creek Floodplain	Data collection following a flood event	\$5,000	\$2,000	\$29,818	NC	N/A	N/A	N/A	0	2	0	0.5	0	0	2	2	2	1.2	0	0	0.0	2.2	8
* Indicates hydraulic model and detailed economic assessment used																									
NC - Not Costed																									